Groundwater Movement and Loss through Ponds in Restored Meadows

Adam McMahon
Graduate Student
Program of Hydrologic Sciences
University of Nevada-Reno

Dr. Sherman Swanson
Associate Professor/Range and Riparian Extension State Specialist
University of Nevada-Reno

Overview

- Project Background
- Objectives
- Hypotheses
- Study Area
- Methods
- Analysis
- Application

Project Background

- Meadow Degradation
  - Caused by historical land uses
  - Results in down cut stream channels
    - Decreased groundwater levels
    - Loss of wet-meadow vegetation
    - Increased erosion and sediment load
    - Increased flood flows

Project Background

- Meadow Restoration
  - Pond-and-Plug
  - Returns stream to original floodplain
    - Increased groundwater levels
    - Return of wet-meadow vegetation
    - Increased floodplain inundation
  - Ecologically Successful

Project Background

- Post-Restoration and Water Budget
  - Increased groundwater storage
  - Increased evapotranspiration
  - Modified groundwater flow paths
  - Stream flow changes
    - Decreased flood peaks
    - Increased flows post runoff
    - Late summer base flows?

Objectives

- Examine interactions between ponds and streams
  - Ponds may represent a sink for surface water flows via flood capture and evapotranspiration
- Examine groundwater flow through meadows
  - Water may flow through meadows differently and thus affect stream flow

Hypotheses

- Ponds and streams interact, with ponds possibly acting as a sink during baseflows
- Groundwater flow may fit one of three conceptual models
- Local characteristics (gradient, geology, hydraulic conductivity) could influence groundwater flow and pond/stream interactions

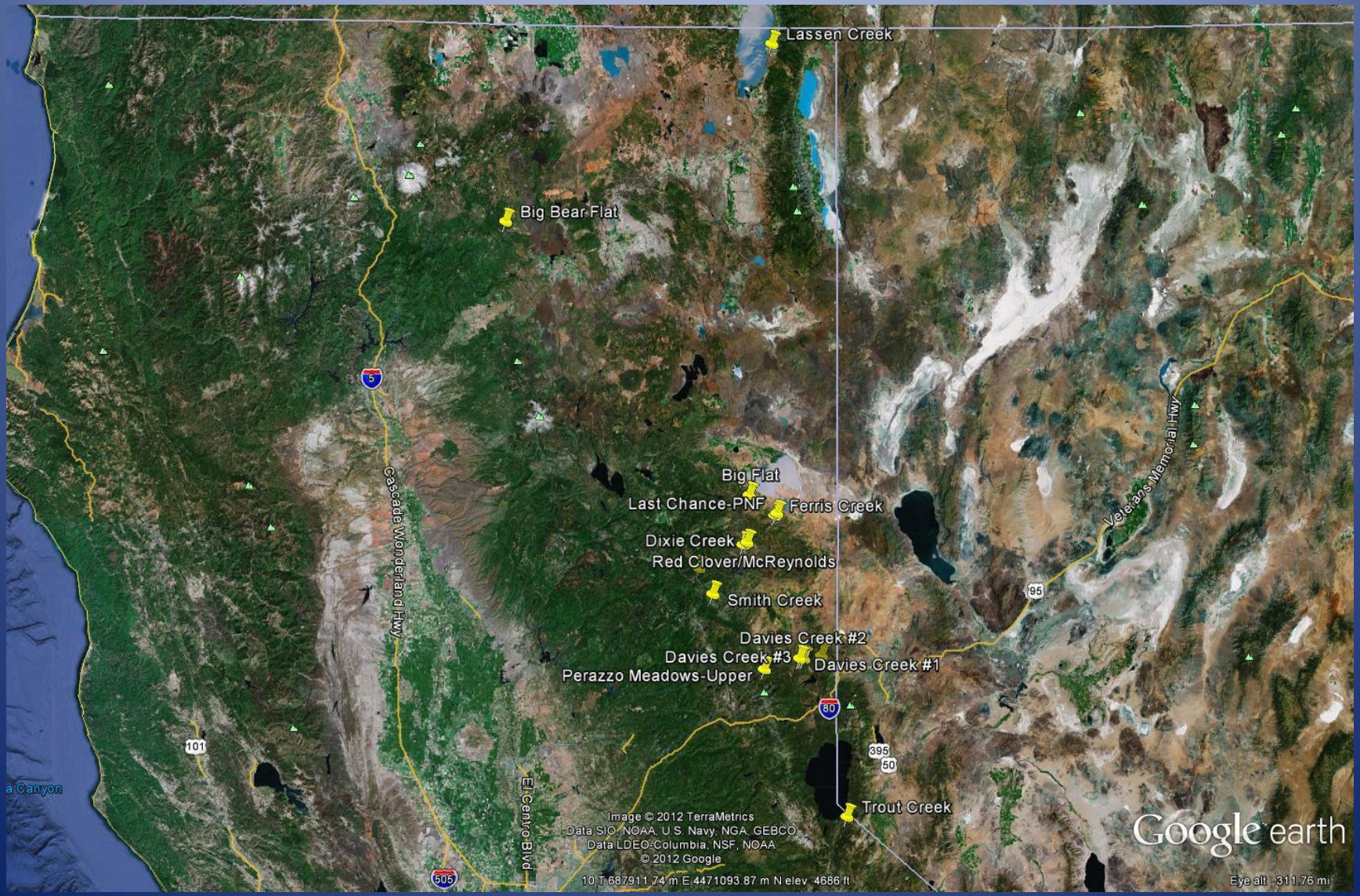
Conceptual Meadow Models

- Sponge
  - High permeability
  - Absorbs snowmelt and runoff
  - Releases stored water to stream post runoff
- Valve
  - Lower permeability
  - Slows discharge of groundwater to stream
- Drain
  - Variable permeability
  - Acts as recharge area for regional aquifer

Study Area

- Sierra Nevada Mountain Range
  - National Forest and private lands
  - Snowmelt driven hydrology
  - Mixed water uses
    - Agriculture
    - Ranching
    - Reservoir storage
    - Wildlife

Study Area


Lassen Creek
Big Bear Flat
Big Flat
Last Chance-PNF
Ferris Creek
Dixie Creek
Red Clover/McReynolds
Smith Creek
Davies Creek #2
Davies Creek #3
Davies Creek #1
Perazzo Meadows-Upper
Trout Creek
Cascade Wonderland Hwy
Veterans Memorial Hwy
El Centro Blvd
5
95
80
101
395
50
505
Image © 2012 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Data LDEO-Columbia, NSF, NOAA
© 2012 Google
10 T 687911.74 m E 4471093.87 m N elev. 4686 ft
Google earth
Eye alt 311.76 mi

Study Area

- 17 Study Sites
  - Selection Criteria
    - No surface interaction between ponds and streams (for at least 3 ponds and at low flows)

Site Name	Number of Study Ponds	Number of Water Level Loggers
Big Flat	10	5
Ferris Creek	8	5
Dixie Creek	7	2
Long Valley Creek	13	5
Merrill Valley #9	13	5
Davies Creek #2	8	3
Davies Creek #1	10	3
Perazzo Meadows-Upper	17	5
Davies Creek #3	6	2
Last Chance-PNF	19	2
Smith Creek	6	3
Red Clover/McReynolds	6	2
Rose Canyon Creek	10	5
Big Bear Flat	11	5
Trout Creek	10	1
Lassen Creek		2
Bagley Creek II	3	2

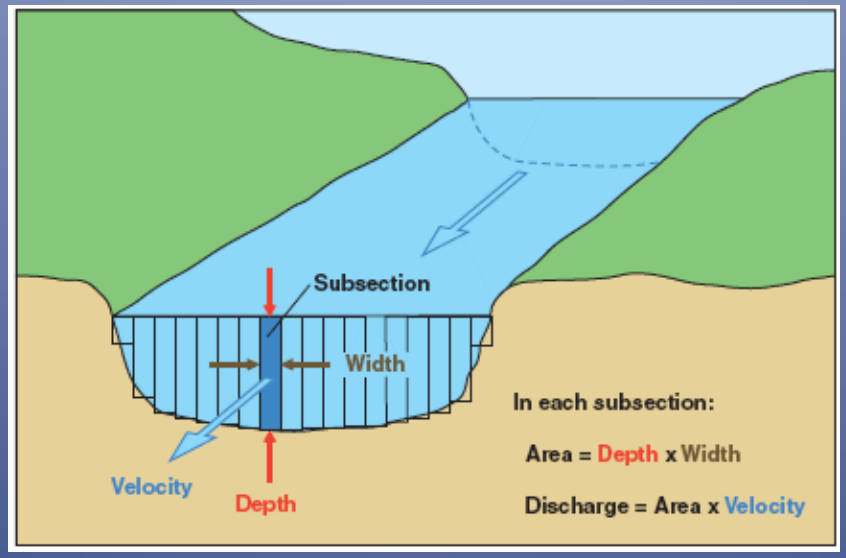
Methods

- Monitor stream and water levels through the season
  - Install water level loggers with staff gage in stream channel up and down stream
  - Install water level logger in pond(s) with staff gage
  - Survey water levels at least four times through season, in ponds and in adjacent stream channel

http://www.solinst.com/Prod/3001/3001d6.html

Methods

- Measure discharge at stream level loggers



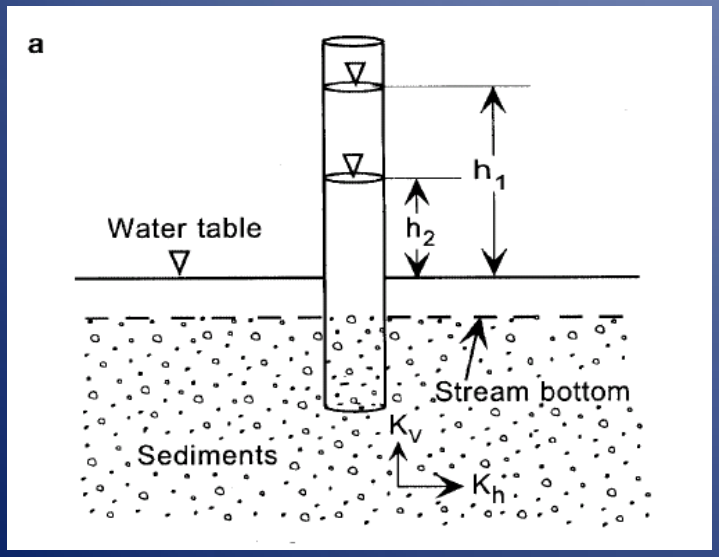
http://ga.water.usgs.gov/edu/streamflow2.html

Methods

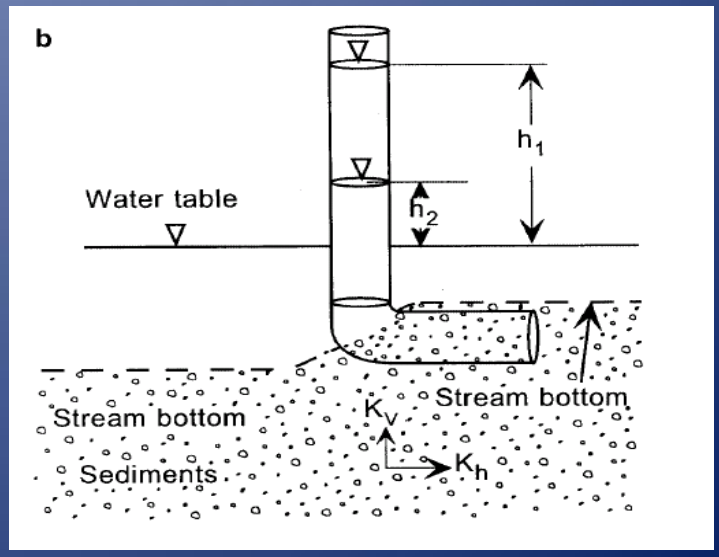
- Davies Creek #2

Methods

- Measure vertical and horizontal hydraulic conductivity in ponds using standpipe methods (Chen, 2000)



Chen (2000)



Chen (2000)

Methods

- Survey aspect and gradient
- From online resources collect
  - Geologic parent material
  - Precipitation data

http://www.conservation.ca.gov/cgs/cgs_history/Pages/2010_geologicmap.aspx

Analysis

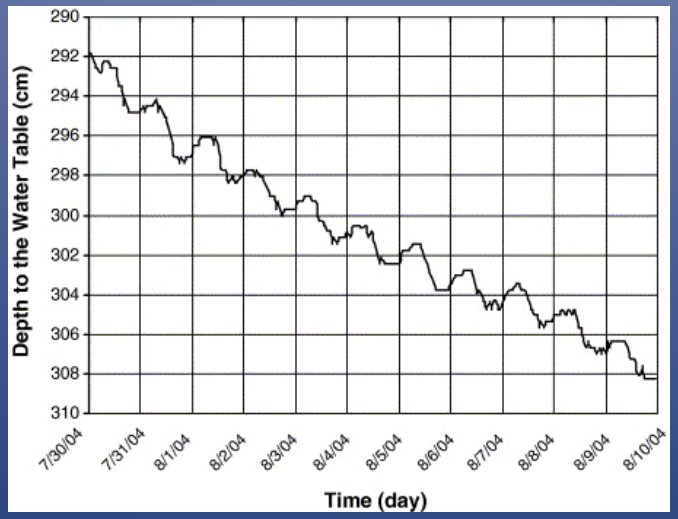
- Stream and Pond Interactions
  - Compare water levels through season
    - Similar increasing/decreasing rates could indicate interaction
    - Lower pond levels than stream in late summer could indicate stream water flowing to ponds and loss through evaporation

Analysis

- Groundwater Flow Model
  - Compare water levels in ponds through season
    - Downhill and pond to pond
    - Could indicate groundwater flow paths, and whether meadow fits sponge, valve, or drain conceptual model
  - Compare hydraulic conductivities
    - In combination with water level comparison, could indicate whether meadow fits conceptual model

Analysis

- Evaporation
  - Estimated using methods from White (1932), Loheide (2008), and Hill et. al. (2007)
    - Use diurnal fluctuations in pond level loggers
    - Could indicate groundwater recharge
    - Indicate water loss from ponds into atmosphere



Chen (2006)

Analysis

- Hydrograph
  - Create rating curve from discharge measuring and water level recordings
  - Compare hydrographs from upstream and downstream of project area

Analysis

- Synthesis
  - Use discriminate analysis to compare measured values (stream/pond interactions, hydraulic conductivity) with landscape characteristics (slope, aspect, geology)
  - Determine what factors (if any) influence groundwater flow and stream/pond interactions

Summary

- Further understanding of pond and stream interactions
- Examine meadow conceptual models
- Compare meadow to meadow
- Provide knowledge for practitioners and managers

Acknowledgements

- Funding
  - California DWR and National Fish and Wildlife Foundation through the US Forest Service
  - Sierra Nevada Conservancy
- Supporting Data
  - Feather River Coordinated Resource Management
  - StreamWise